International Journal of Agricultural Sciences
Volume **15** | Issue 2 | June, 2019 | 275-282 ■ ISSN : 0973-130X
DOI:10.15740/HAS/IJAS/15.2/275-282
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RESEARCH PAPER

Supply response of indian maize farmers - A conceptual analysis

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Abstract : Maize is the third most important cereal and it is cultivated throughout the year. Maize consumption is growing at a compound annual growth rate (CAGR) of 11 per cent in last 5 years. To meet the growing demand, maize production must grow at 15 per cent CAGR, while the current CAGR is only 4 per cent. Consequently, import of maize to India has increased exponentially. Hence, there is a need to increase the production in India in order to reduce the increasing imports and to meet the domestic demand. There are various factors that influence the crop output. This study proposes to identify the factors influencing maize acreage in India by appraising significant six supply response functions in order to strategize policies for improvement of maize production. Koyck second order lag model which incorporated two year lag of area under the crop, one year lagged price of the own crop and competitive crop (groundnut) and minimum support price in the current sowing season was found to be the well suited model to analyze the supply response of Indian maize farmers. The study suggests the government to promote market information among the farmers and to procure the produce from the farmers based on minimum support price.

Key Words : Supply response, Area response, Nerlovian model

View Point Article : Keerthiga, A. Angelin, Gopal, S. Murali and Priyanka, P. Asha (2019). Supply response of indian maize farmers - A conceptual analysis. *Internat.J.agric.Sci.*, **15** (2) : 275-282, **DOI:10.15740/HAS/IJAS/15.2/275-282.**

Article History : Received : 24.01.2019; **Revised :** 10.05.2019; **Accepted :** 18.05.2019

INTRODUCTION

Maize (*Zea mays* L.) or corn is known as 'Queen of Cereals' and is the third most important cereal, after rice and wheat, for human food. It is the most versatile crop and is grown in more than 166 countries across the globe. Maize directly contributes almost 10 per cent to the Indian food basket and 5 per cent to the world dietary energy supply. In India, it is cultivated throughout the year for various purposes that include grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn, starch and industrial products like bio fuel, bio ethanol etc.

The area under the crop worldwide is 183.68 Million hectares (M ha) in 2017-18, down from 186.91 M ha in 2016-17. The yield is reduced to 5.63 metric tonnes per hectare (MT/ha), from 5.77 MT/ha previous year. Global maize production touched approximately 1040 Million MT (MMT) in 2016-17, wherein, US (38%) and China (23%) has been the leading producer. Major importers include Japan, Mexico, European Union, South Korea and Egypt

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(USDA, 2018).

The production and consumption of maize have been rising frequently in India. Major maize growing states in India are Maharashtra, Rajasthan, Gujarat, Karnataka, Madhya Pradhesh, Andhra Pradesh, Tamil Nadu and Telangana. Increased adoption of improved hybrids, particularly single cross hybrids, has encouraged farmers to bring more area under maize cultivation. Consequently, area under maize has gone up with 3 per cent CAGR to 10.2 M ha in 2016-17. In 2017-18 corn acreage is likely to come down to 9.5 M ha due to unstable prices. India contributes around 2 per cent of global maize production with a quantum of 28 MMT in 2017-18 (FICCI, 2018).

Indian maize is performing around 130 per cent low in terms of yield as compared to world average. The average productivity of maize in India is 3.12 MT/ha (Ministry of Agriculture and Farmers Welfare, 2018). This is due to various factors like rainfed cultivation of maize, small land holding, GMO restrictions and reduced crop protection measures. Indian corn is uncompetitive in the international market due to relatively weak international prices. Major export destinations of Indian maize are Nepal, Bangladesh, Philippines, Myanmar and Sri Lanka (Ministry of Agriculture and Farmers Welfare, 2018). Also import of maize to India has seen a drastic increase from 1 MMT in 2016-17 to 4 MMT in 2017-18 (FAO, 2018). This sudden increase is due to strong growth in livestock and poultry industry.

During 2017-18, maize consumption has increased by 2 per cent to 24 MMT over previous year. It includes 13.5 MMT for poultry feed, 1.8 MMT for starch, 1.2 MMT for ethanol, and balance for food, seed and other uses. Maize consumption is growing at a compound annual growth rate (CAGR) of 11 per cent. To meet the growing demand, maize production must grow at 15 per cent compound annual growth rate, while the current CAGR is only 4 per cent (FICCI, 2018). There is a pressing need to increase the production in India in order to reduce the increasing imports to meet the domestic demand. The growth in the crop output is contributed by various factors. The change in these factors may cause a positive or negative growth rates in the crop output. The quantitative assessment of these factors will be helpful in re-orienting the programmes and priorities of agricultural development so as to achieve higher rates of growth. Therefore, the study of maize supply response is of considerable importance for devising a suitable policy for agricultural sector. In this context, this study proposes to analyze the factors of supply response to conceptually identify the appropriate strategies to improvise the supply of maize in India.

Agricultural pricing policy plays a key role in increasing both farm production and incomes and fundamental to an understanding of this price mechanism is supply response (Nerlove and Bachman, 1960). Area allocation represents both production target and response to price. If future trend of market price is informed before production, then the scarce resources can be allocated in a planned way (Huq *et al.*, 2013). The total supply response is the response of the total output to price and non-price factors (Gurikar, 2007).

The relationship between expected prices and farmers decisions is best expressed in terms of the acreage planted because this is how farmers translate their price expectations into action (Askari and Cummings, 1977). The effects of changes in relative price on acreage have been studied by Nerlove (1958); Behrman (1968) and Fisher and Temin (1970). The crop acreage is a function of lagged real crop price, lagged yield and lagged acreage of the crop and its competitor and a rainfall index compiled for the sowing period as indicated by Madhavan (1972); Kalirajan and Flinn (1981); Narayana and Shah (1984); Cauvery (1992); Mesfin (2000); Pandey *et al.* (2012); Haile *et al.* (2015) and Magrini *et al.* (2016).

Farmers are responsive to crop's own price and non - price incentives and also farmers allocate land to crops mainly based on their previous allocation rather than relative crop prices as indicated by Lahiri and Roy (1985); Rao (1989); Kuombola (2007) and Lawrence *et al.* (2007). A study by Ashok (2004) indicated that influence of rainfall and lagged yield were not significant, while lagged area and lagged price had a significant positive influence on area. This was also suggested by Barman and Hazarika (1995) and Diebold and Lamb (1997). Study by Orefi *et al.* (2015) revealed that own crop price had a significant influence on the area of the crop and he suggested that positive price policy would surely encourage farmers to bring more area under the crop.

According to Askari and Cummings (1977), the inclusion of a time trend variable instead of specific variables is justified if there is a lack of data or if there is multicollinearity among variables. In this case, the time trend variable would act as a proxy for improvements in technology and other farming methods over time.

However, Mamingi (1997) warns that omitted variables should only be captured by the use of a time trend variable as a last resort, since the aim of the model is to determine the impact of specific variables.

Material and Methods

Methodology and model:

The present study was carried out based on secondary sources of data from 1990-91 to 2016-17. The data required for the study were area under maize in India, yield of maize, wholesale price of maize, wholesale price of groundnut, average annual rainfall, minimum support price of maize and average cost of cultivation of maize. These information were collected from the sources *viz,* various issues of Agricultural Situation in India and authenticated published sources of the Government of India. The Ministry of Agriculture, FAOSTAT, Directorate of Maize Research and USDA data bases were helpful in getting required data for the study. Other related information were sourced through Ministry of commerce and Industry (2017) and other reputed secondary data sources.

The study has utilized the six different models identified by Alemayehu Geda (1977) in the supply response studies of producers of annual crops. They are:

– Simple koyck distribution lag model or Simple Nerlovian expectations model

– Complex nerlovian expectations model

– Koyck second order lag model

– Nerlovian adjustment model

– Expectations adjustment model and

– Simple model

Variables used in the model are as follows:

– A_t is the area of maize crop in the current year (ha)

– P_t is the own price of maize in the current year (Rs./MT)

– Y_t is the yield of maize crop in the current year (MT/ha)

– R_t is the average annual rainfall in the current year (mm)

– PC_t is the price of competing crop (Groundnut) in the current year (Rs./MT)

– MSP_t is the minimum support price of maize in the current year (Rs./MT)

– COC_t is the cost of cultivation of maize in the current year (Rs./ha)

– T is the trend variable

– U is the error term

– t-1 and t-2 represent one and two year lagged values of the variable.

Simple koyck distribution lag model/ simple nerlovian expectations model:

The model is based on the concept that the importance of past prices declines in a geometric progression. Based on the theory, a simple Koyck Distribution lag model or simple nerlovian expectations model was framed as below:

$$A_t = a_1 + b_1 A_{t-1} + c_1 P_{t-1} + d_1 R_{t-1} + e_1 PC_{t-1} + T + U$$

Complex nerlovian expectations model:

The complex nerlovian expectations model postulates different expectation lag co-efficients (expected price) for the expectational variables. Complex nerlovian expectations model to understand the supply response of maize was designed as follows:

$$A_t = a_2 + b_2 A_{t-1} + c_2 P_{t-1} + d_2 Y_{t-1} + e_2 PC_{t-1} + f_2 R_{t-1} + g_2 A_{t-2} + h_2 P_{t-2} + i_2 Y_{t-2} + j_2 PC_{t-2} + f_2 R_{t-2} + U$$

Koyck second order lag function:

Koyck second order lag function uses lagged dependent variable as a regressor under the assumption of slow response due to institutional factor. The use of a two-period lagged area is based on the observation that peak response takes place after a time-lag of two periods. The farmer may be traditionally slow in responding or institutional factors may force him to delay his responses. The model framed for the study is as follows:

$$A_t = a_3 + b_3 A_{t-1} + c_3 A_{t-2} + d_3 P_{t-1} + e_3 MSP + f_3 PC_{t-1} + U$$

MSP is being calculated based on the cost of production, inter-crop price parity, international price situation, export-import policy and many other variables (Ministry of Agriculture, 2018). MSP acts as a representation of these variables. Hence, MSP was included as an institutional variable in the model.

Nerlovian adjustment model:

Nerlovian adjustment model defines the changing aspects of agricultural supply by incorporating price expectations. The model for the study was designed as:

$$A_t = a_4 + b_4 A_{t-1} + c_4 P_{t-1} + d_4 Y_{t-1} + e_4 PC_{t-1} + f_4 R_t + U$$

Expectations - adjustment model:

Ideally a model of supply response should incorporate a separate lag co-efficient for each expectational variable and a different adjustment lag co-efficient. Based on the theory a simple expectations – adjustment model was formulated as follows:

$$A_t = a_5 + b_5 A_{t-1} + c_5 P_{t-1} + d_5 COC_{t-1} + e_5 R_t + f_5 PC_{t-1} + T + U$$

Simple model:

The simple model which has neither adjustment nor expectation variables, attempts to take into consideration some of the slowly changing factors such as institutional or technological changes over time. It is a one equation model, as the estimating equation is the same as the original supply function.

$$A_t = a_6 + b_6 P_{t-1} + c_6 Y_{t-1} + d_6 R_t + e_6 PC_{t-1} + T + U$$

All the supply response models discussed had made use of nerlovian model. The differences were only in the selection of variables and the consequent changes in estimation procedures.

Results and Discussion

The co-efficients of area response of the maize for all the six supply response models were computed by fitting the linear multiple regression equations. The estimated regression co-efficients of different supply response models were presented as follows.

Simple koyck distribution lag model / simple nerlovian expectations model:

The estimated supply response model is:

Adjusted R square= 0.977			
$A_t =$	1139.47	+0.308 A_{t-1}	+ 1.87 P_{t-1}
t-Stat	0.981	2.356	1.420
p-Value	0.338	0.029	0.171
F statistics: 166.284			
$A_t =$	+ 0.209 R_{t-1}	- 0.253 PC_{t-1}	+0.405 T + U
t-Stat	0.386	-2.161	2.058
p-Value	0.703	0.043	0.053

The smaller values of area adjustment (A_{t-1}) co-efficient signified high degree of constraints in the adjustment process. The adjustment of area to the desired level required fairly long-period of time. The lagged price of maize (P_{t-1}) was a significant factor with the co-efficient of 1.8662. It infers that farmers of India consider one year lagged price while taking decision regarding current year area allocation under maize crop. The co-efficient of lagged price of competitive crop, PC_{t-1} (-0.2529) was negatively significant.

The co-efficient of trend, T (0.4048) was significant at 5 per cent level. Un-quantified impacts, like technology improvements and increase in efficiency, were captured by the simple time trend variable. The rainfall co-efficient (R_t) was estimated to be 0.2087 but it was not significant. The insignificant co-efficients imply that these variables had no definite consequences on the variation in the area. The overall significance of the model was found to be satisfactory.

Complex nerlovian expectations model:

The estimated complex nerlovian expectation supply response model is:

Adjusted R square = 0.974						
A_t=	1583.95	-1.19P_{t-1}	+0.4A_{t-1}	-0.32Y_{t-1}	-0.24PC_{t-1}	
t Stat	0.936	-0.743	1.604	-0.822	-1.897	
P-value	0.364	0.469	0.13	0.424	0.077	
F statistics: 93.619						
A_t=	-0.42R_{t-1}	+0.64A_{t-2}	+2.8P_{t-2}	-0.21Y_{t-2}	-0.08PC_{t-2}	-0.42R_{t-2}+U
t Stat	-0.8	2.704	2.074	-0.561	-0.527	-0.781
P-value	0.436	0.016	0.056	0.583	0.606	0.447

From the results, the co-efficient of two year lagged area of maize, A_{t-2} was found to have significant influence over the area. Also it was observed that one and two year lagged price of maize (P_{t-1} and P_{t-2}), were also a major factor that has impact on the acreage response. Wherein, the co-efficient of P_{t-2} (2.8839) was found to be significant at 5 per cent level. This is however, may be because of the increase in the prices of maize were not to the extent that induced farmers to allocate more area to this crop and absence of adequate support and remunerative price policies.

The co-efficient of one and two years lagged price of competitive crop (PC_{t-1} and PC_{t-2}) were -0.2414 and -0.0778, respectively. But only PC_{t-1} was found to have significant influence on the area response of maize. Also yield of the crop in the past (Y_{t-1} and Y_{t-2}) influences the allocation of area under maize in the current year. The estimated regression co-efficients of Y_{t-1} and Y_{t-2} were -0.3196 and -0.2160, respectively. But the yield did not have any notable influence on the dependent variable as their values were found to be insignificant.

From the results, it was noted that this model doesn't fit well for the current study. As a result of serious estimation problems, complex nerlovian expectations model which assumes different expectation lag coefficients for expectational variables is seldom used.

Koyck second order lag function:

The fitted koyck second order lag function is:

Adjusted R square= 0.975			
$A_t =$	2342.85	$+0.474\ A_{t-1}$	$+1.075\ A_{t-2}$
t-Stat	1.840	2.239	3.834
p-Value	0.081	0.037	0.001
F statistics:192.712			
$A_t =$	$+2.216\ P_{t-1}$	$+1.482\ MSP_t$	$-0.208\ PC_{t-1} + U$
t-Stat	2.109	2.506	-2.665
p-Value	0.048	0.021	0.012

Based on the theory, A_{t-2} was included as an independent variable. The low magnitude of the area adjustment co-efficient (A_{t-1}) indicated that there existed institutional and technological barriers against the yield adjustment with the changes in prices. The significant co-efficient of A_{t-2} implies that peak response happens only after two year periods. This is due to the lack of market information to all the farmers. Those with more access to market information will respond quickly than others.

Along with area, P_{t-1} was also found to influence the current year allocation of area under maize. Being an institutional factor, minimum support price of maize (MSP_t) announced at the beginning of the sowing season also decides the area response of maize. The co-efficient of MSP_t was 1.4820 with 5 per cent significance. Also PC_{t-1} was significant, with co-efficient value of -0.2075. It implies that with an increase in lagged price of groundnut, the area under maize in the current season decreases by 0.21ha.

Nerlovian adjustment model:

The model fitted for nerlovian adjustment model is:

Adjusted R square = 0.966			
$A_t =$	913.42	$+0.61\ A_{t-1}$	$+ 2.25\ P_{t-1}$
t-Stat	0.624	3.136	2.723
p-Value	0.540	0.005	0.013
F statistics: 142.126			
$A_t =$	$+ 0.133\ Y_{t-1}$	$-0.301\ PC_{t-1}$	$+ 0.734\ R_t + U$
t-Stat	0.287	-2.378	0.976
p-Value	0.777	0.028	0.341

The results show that P_{t-1}, A_{t-1}, $Y_{t-}1$ and R_t all exert a positive influence on maize output. The co-efficient of A_{t-1} also called area adjustment factor (0.6102) was significant. The co-efficient of P_{t-1} and Y_{t-1} indicates that an increase in price and yield in the past year will be followed by an increase in output in the subsequent period. But the influence was insignificant.

The co-efficient of PC_{t-1} alone exerts a negative influence on the dependent variable, whose co-efficient was -0.3011. The insignificant estimated co-efficient of rainfall variable suggests that rainfall is not very crucial to maize output. This implies that reformation of existing irrigation programmes will be viable. The continuous drought in maize producing areas of India had a significant negative impact on maize production over time. These variables together explain about 97 per cent of the variation in Indian maize output.

Expectations - adjustment model:

The estimated supply response model is:

Adjusted R square = 0.979				
$A_t =$	154.72	$+0.37\ A_{t-1}$	$+ 1.65\ P_{t-1}$	
t-Stat	0.130	2.115	1.775	
p-Value	0.899	0.048	0.092	
F statistics: 148.352				
$A_t =$	$+ 0.11\ COC_{t-1}$	$+ 0.87\ R_t$	$-0.24\ PC_{t-1}$	$+0.39\ T + U$
t-Stat	0.311	1.585	-2.003	1.929
p-Value	0.759	0.129	0.059	0.069

The results revealed that maize area was significantly influenced by P_{t-1} and PC_{t-1}. When P_{t-1} rises, farmers choose to increase the share of their land allocated to maize cultivation by 1.6499 ha. When PC_{t-1} rises by a unit, farmers react by decreasing the land for maize production by 0.2351 per cent, as indicated by the regression co-efficient.

Maize area response show no evidence of responsiveness to cost of cultivation of maize lagged by one year (COC_{t-1}), as its co-efficient 0.1077 was found to be insignificant. This doesn't imply that cost of cultivation is unrelated with area response, but the net income from the crop is reasonable and the farmers do not hesitate to invest in a viable crop. Although rainfall has some impact on maize supply response, its regression co-efficient values implies its minimal influence.

Simple model:

The simple model estimated in the study was:

Adjusted R square = 0.976			
A_t =	573.94	+ 2.176 P_{t-1}	+ 0.223 Y_{t-1}
t-Stat	0.415	2.913	0.532
p-Value	0.683	0.009	0.601
F statistics: 162.375			
A_t =	-0.272 PC_{t-1}	+ 1.016 R_t	+0.573 T + U
t-Stat	-2.273	1.448	3.737
p-Value	0.034	0.163	0.001

From the results, co-efficient of P_{t-1} was significant at 1 per cent level. The adoption of fertilizer and other methods of improved yield practices would expand maize production. This is revealed by the highly significant co-efficient of T which stands as a proxy for yield increasing technologies. PC_{t-1} was low and negative (-0.2721), which indicates that A_t decreases when PC_{t-1} increases as farmers turn towards producing more of groundnut. This was evident as farmer's decisions are market driven. The study revealed that Y_{t-1} and R_t were positive but not significant. This indicated that farmers does not consider rainfall before allocating their land, as only 20 per cent maize in India is grown under irrigated condition.

Summary and conclusion:

Estimation of supply response will help to know the influence of major supply deciding factors on responsiveness of farmers to these factors. Empirical studies of supply responses to price changes provide the basic material for the consideration of price incentives to boost agricultural production.

With reference to the earlier discussion, each model is significant in its own way. The best suited model is the one with comparatively higher significance than other models. As far as maize crop is concerned, Koyck second order lag model was found to be the model with greater number of significant independent variables. Also the signs of co-efficients of all the variables and F-statistics value were logical and rational. Finally, Koyck second order lag model suites well to analyze the supply response of Indian maize farmers.

From the study the factors that has to be considered while framing policy regarding increasing production of maize in India are, area under the crop in the past two years, price of the crop in the previous year, price of the competitive crop (groundnut) and minimum support price announced in the current sowing season.

Policy implications:

The following policy implications may be considered for further research and development based on above results.

The decline in area under maize indicated that the infrastructure and extension services should be strengthened for bringing more awareness in the farming community on new technological innovations. The decrease in area under maize can be overcome by introducing yield improving technologies to increase the farmer's income. Also promoting the area under maize can be done by implementing some subsidies and incentive schemes.

The response of the farmers is delayed due to deficit market information as indicated by the significance of two year lagged area under maize crop. In order to increase the response of the farmers, market information must be promoted among the farmers.

Since the farmers' response to prices is quite significant, the pressing need of the hour is to have a positive and remunerative price policy for maize. It is high time that we should have thought of remunerative price rather than support price in an agricultural price policy.

The area response of farmers to minimum support price of the crop is positive and significant. But in many states except few, the actual procurement of the produce

Table 1 : Comparison between models

Name of the model	No. of regressors	No. of significant independent variables	Adjusted R square	F – statistics
Simple koyck distribution lag model	5	3	0.971	166.285
Complex nerlovian expectations model	10	3	0.974	93.619
Koyck second order lag function	5	5	0.975	192.712
Nerlovian adjustment model	5	3	0.973	142.126
Expectations - Adjustment model	6	4	0.979	148.352
Simple model	5	3	0.976	162.375

based on MSP does not happen. So, along with the announcement of MSP it is necessary to procure the produce from the farmers by the Government.

Also there is a need for research to find out the problems faced by the farmers in order to tackle them and increase maize production in India.

Acknowledgement:

This research exertion has been done in part fulfillment of the requirement for the degree of Master of Science in Agricultural Economics to Tamil Nadu Agricultural University, Coimbatore.

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15th Year
★★★★★ of Excellence ★★★★★